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# Photoionization Cross-Sections and Rydberg Resonance Identifications of Br+

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# Photoionization Cross-Sections and Rydberg Resonance Identifications of $Br^+$

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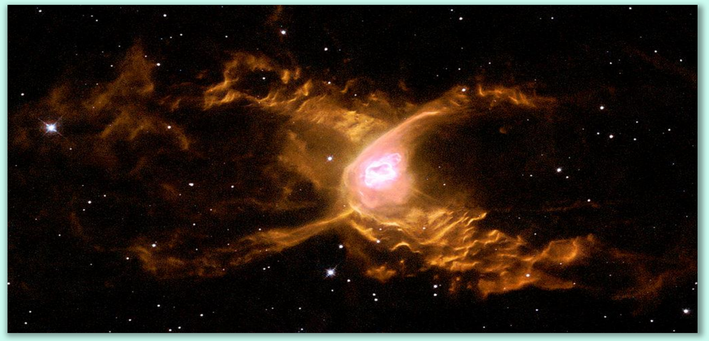
## MOTIVATION

Astrophysicists often need atomic data for elements that are detected in astrophysical nebulae. Because trans-iron elements have recently been detected, specifically in planetary nebulae, and have very little atomic data, our goal has been to determine absolute single photoionization for trans-iron elements. The present analysis' purpose is to find photoionization cross-sections, to find and validate direct ionization thresholds and excited state energy levels and to identify Rydberg series in photo-ion spectroscopy of $Br^+$ ions.

A few examples of planetary nebula can be seen to the right.

NGC 5189 Nebula

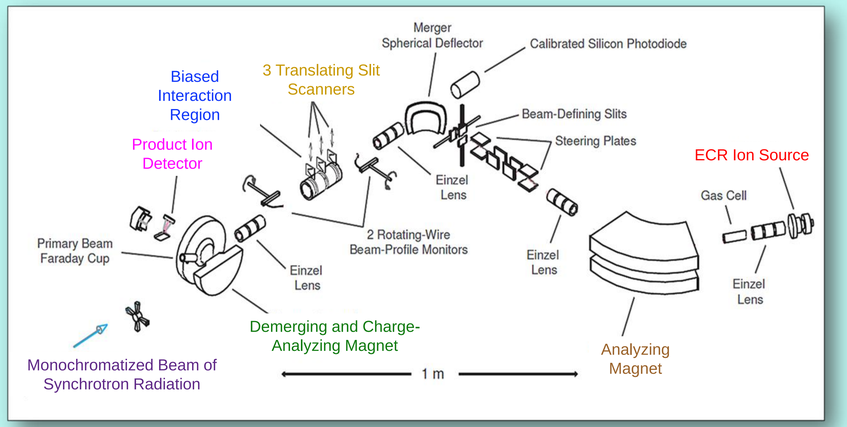


Red Spider Nebula (NGX 6537)

## EXPERIMENT

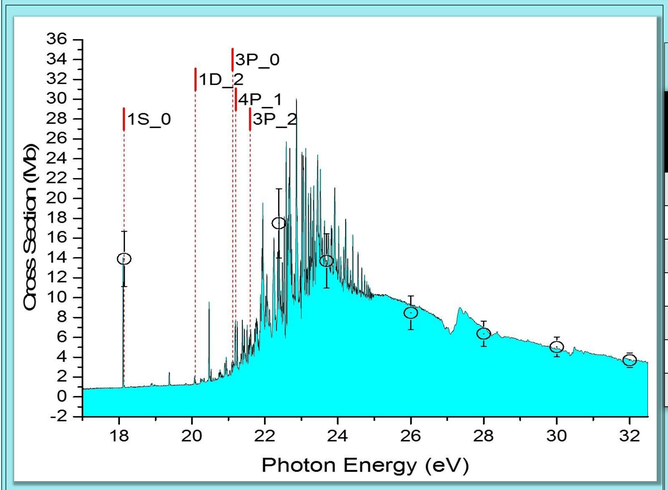
The Advanced Light Source at Lawrence Berkeley National Laboratory uses a linear electron accelerator and booster ring placed within the main storage ring.

**Experimental Technique:** Positively charged Br ions are created in the electron-cyclotron-resonance (ECR) ion source. $Br^+$ ions are mass-charged selected using a 60° analyzing magnet and then merged with the monochromatized photon beam. 3 translating slit scanners within the 29.4 cm long biased interaction region are used to tune the two beams to have a good overlap. A 45° demerging magnet then separates the $Br^{2+}$ photo ions from the primary ion beam and are sent to the product ion detector [1],[2],[3],[4].




Beamline 10.0.1.2 End Station

## RESULTS

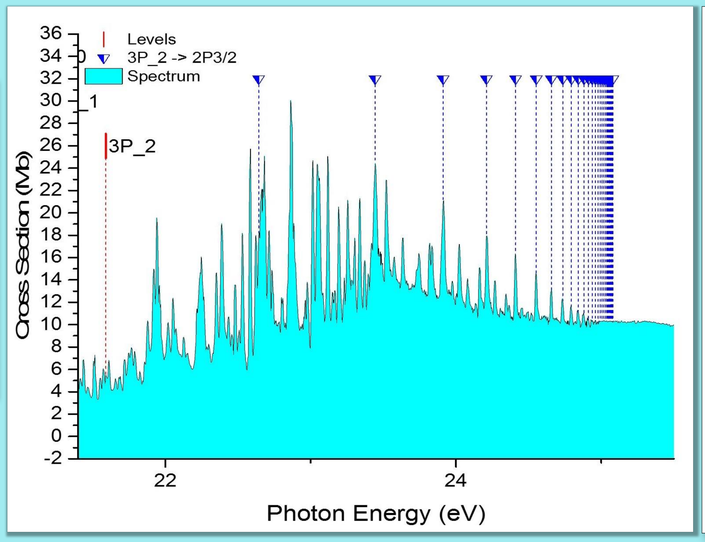


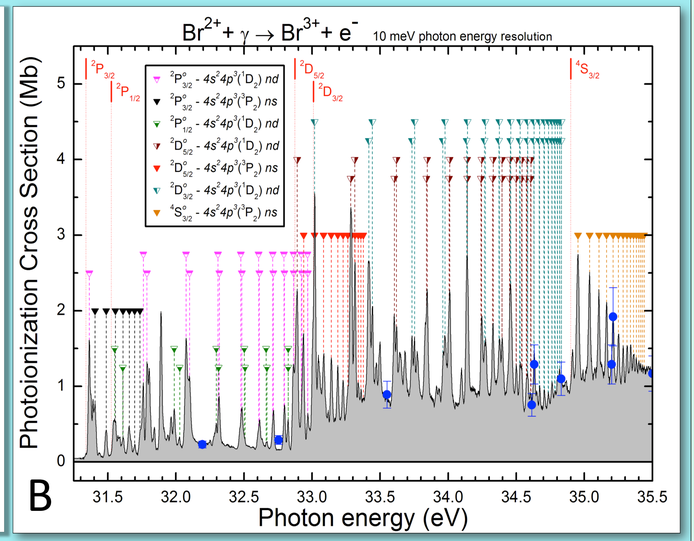

Absolute single photoionization cross section measurements are represented by open circles with ±20% error bars. These exact values are also presented in table 1.

Table 1.

| Energy (eV) | Cross Section (Mb) | Uncertainty (±) |
|---|---|---|
| 18.141 | 13.9116 | 2.78232 |
| 22.386 | 17.5 | 3.5 |
| 23.69 | 13.7 | 2.74 |
| 26 | 8.47 | 1.694 |
| 28 | 637 | 1.274 |
| 30 | 5.03 | 1.006 |
| 32 | 3.7 | 0.74 |

Because these absolute cross section measurements had not been studied to this degree of precision, these data will help astrophysicists to determine abundances of $Br^+$ ions in planetary nebulae.




**Panel A** shows the one identified Rydberg series which originates form the $^3P_2$ parent ion state of $Br^+$ and converges to the $^2P_{3/2}$ final product ion state of $Br^{2+}$. Ionization thresholds and additional Rydberg series are still being determined. **Panel B** shows an example of what our $Br^+$ data should look like after further analysis of the spectrum.

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**References**

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